Uncertainties evaluation in optical fiber grating sensor measurements

Possetti, G. R. C., Lourenço Jr., I., Kamikawachi, R. C., Muller, M., Fabris, J. L.*
Universidade Tecnológica Federal do Paraná, Av. Sete de Setembro 3165, Curitiba - PR, Brazil 80230-901

ABSTRACT

This paper describes an approach to identify, quantify and express uncertainties in optical fiber grating sensor measurements, based on the International Standard Organization's Guide to the Expression of Uncertainty in Measurement. The proposed approach was used to evaluate the uncertainties in the measurements performed with both a fiber Bragg temperature sensor and a long period grating refractometric sensor.

Keywords: Optical fiber grating sensors, uncertainty in measurement, optical metrology

1. INTRODUCTION

In recent years, optical fiber grating sensors based on fiber Bragg gratings (FBGs) and long period gratings (LPGs) have been widely investigated and several industrial applications of such transducers have been reported[1-5]. However, the worldwide acceptance of this photonic technology requires the development of standards and guidelines for specification and testing based on optical metrology[6]. An important issue is the reliability in the measurement performed by optical fiber grating sensors, which is influenced by random and systematic errors. An accurate and precise result can only be obtained if the error sources are identified, quantified and taken into account in the sensor response. Although calibration process can be used to compensate for systematic effects, random effects can not be completely eliminated. Such effects must be quantified and included in the sensor response by means of a doubt range called *uncertainty*, which reflects the lack of exact knowledge of the measurand value. Therefore, the result of a measurement after correction for recognized systematic effects is still only an estimate of the measurand value, because of the uncertainty arising from random effects as well as from imperfect correction of systematic effects. Clearly uncertainty analysis is necessary, but this is often a not well standardized task, making difficult the comparison of the measurements with reference values or with other measurement systems.

The Guide to the Expression of Uncertainty in Measurement (GUM), published by the International Organization for Standardization, establishes general rules for evaluating and expressing uncertainty in measurement[7]. This guide describes international recommendation about uncertainty analysis in measurement and has been used in a wide range of measurements[8-13]. However, the evaluation of uncertainties in optical fiber grating sensor measurements according to GUM is still incipient. The first standard draft on generic specification for optical fiber sensors was published in 1995[14], shortly followed by the publication of the first draft for a specific type of optical fiber sensor (an optical fiber gyroscope) in 1996[15]. However, a guideline for the use of optical fiber sensors containing the definition of basic terms and the description of important sensor features was only released in 2009[16]. In the same year, a guideline on optical FBG based strain sensors was published in Germany[17]. A strain sensitivity calibration of optical FBG-based strain sensors according this guideline was recently reported[18]. Additionally, fundamental limits in FBG peak wavelength measurements were reported in [19]. However, a lack of any approach based on GUM for evaluation of uncertainties in optical fiber grating sensors measurements still remains.

This paper describes an approach to identify and quantify uncertainties in optical fiber grating sensor measurements based on GUM. A fiber Bragg temperature sensor and a long period grating refractometric sensor were characterized according to the proposed approach, and their combined standard uncertainties and expanded uncertainties were determined.

*fabris@utfpr.edu.br; phone 55 41 3310-4642; http://pessoal.utfpr.edu.br/fabris/laser

21st International Conference on Optical Fiber Sensors, edited by Wojtek J. Bock, Jacques Albert, Xiaoyi Bao,
Proc. of SPIE Vol. 7753, 775395 · © 2011 SPIE · CCC code: 0277-786X/11/$18 · doi: 10.1117/12.884911